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THE TEACHING OF MATHEMATICS FOR ENGINEERS[1]

MATHEMATICS, from the standpoint of the engineer, is a means, and not an end. It is an instrument or tool by which he may determine the value and relations of forces and materials.

The usefulness of tools depends upon the sort of work which is to be done, upon the kinds of tools which are available and upon the skill of the man who uses them. We may inquire, therefore, what are the uses to which the engineer may apply mathematics? What kind of mathematics does he need? And what skill should he possess in their use?

First, then, what work is to be done by the young men who are now taking engineering courses? A few—and only a few—will be original investigators or designers who will need mathematics as an instrument of research. A considerable number will regularly employ elementary mathematics in more or less routine calculations. Many will have little use for mathematics, as engineering courses are recognized as affording excellent training for various business, executive and other non-technical positions, particularly in connection with manufacturing and operating companies. It has been stated by the vice-president of a large electric manufacturing company that not over ten per cent. of the technical graduates employed by that

[1] Read before Sections A and D of the American Association for the Advancement of Science and the Chicago Section of the American Mathematical Society, at the Chicago meeting, December 30, 1907.

company are fitted by temperament or by education to take up with success the work of pure engineering. A recent classification of the graduates of Sibley College, Cornell University, shows that about half are in occupations which require no advanced mathematics and it is probable that many of the 36 per cent. classed as mechanical and electrical engineers seldom go beyond the rules of arithmetic. Hence a goodly proportion of engineering graduates do not need to be mathematical experts. Their mathematical studies need not aim to produce experts, but should have as a principal object the mathematical training which is a most efficient kind of training in an engineering course. On the other hand, the engineers who will have practical use for the higher mathematics will find their ability as engineers is in a large measure determined by their ability as mathematicians.

Second, the question, what kinds of mathematics does the engineer need? is closely related to the class of work he is to do. In general a great deal of engineering work is done with much less use of higher mathematics than most professors probably imagine; and furthermore, it may be remarked, with much less than could profitably be employed. Engineers are apt to use ordinarily the mathematical methods with which they are most familiar and which will bring the result with the least effort. One man employs calculus, another draws a diagram, another writes out formulæ, while another gets his results by mental arithmetic. The object is to get the result.

The fundamental idea that mathematics is something for the engineer to use finds many illustrative analogies in ordinary tools. Adaptation is the first requisite. Tools should be suited to the work to be done. An expensive machine tool with its refined adjustments is quite unnecessary for executing a piece of work which can be done with sufficient accuracy by a few minutes' application of a file. An ordinary calculating slide rule is infinitely better than a table of seven-piece logarithms in every-day work.

On the other hand, it is particularly wasteful to attempt to execute a difficult and intricate piece of work with inadequate tools. But more important than the tool is the skill of the man who uses it. A skillful workman can accomplish results with a few simple tools which others can not get with the most elaborate special equipment.

Third, therefore, skill in the use of mathematics is the really essential thing. A judicious use of arithmetic with a little algebra or a simple diagram often leads to more satisfactory results than others secure through elaborate processes involving lengthy equations and complicated operations. In the latter, errors are liable to occur, the common-sense import of the problem is apt to be overlooked, assumptions may be made to facilitate calculations which are physically unwarranted as one loses sight of the physical problem in the intricacy of the mathematical solution. Abstract mathematical studies, if pursued as a kind of intellectual calisthenics, may produce a pure mathematician, but they may unfit a man for practical engineering. A mathematician is not necessarily an engineer; nor is an elocutionist necessarily a good lecturer, nor is a tool expert a successful manufacturer.

Mathematics is used in engineering to express the quantitative relations of natural phenomena. The mathematician delights in the relations: he divorces them from the phenomena and gives them abstract expression, while the engineer is concerned with the natural phenomena; he demands the physical conception; the me-

dium of expressing these relations is of secondary consequence.

The mathematician evolves the equation for a parabola and finds a convenient illustration in the law of projectiles. The engineer finds that a physical result follows from the application of certain forces, and uses the formula merely as a convenient method of expressing the law. The analogue in the case of mechanical tools is found by regarding a set of drawing instruments or a transit or a lathe, as something intelligently designed, properly proportioned, accurately made and finely finished, the merit of which lies in its own inherent excellence; or, on the other hand, by considering them as tools adapted for doing a certain range and character of work with a sufficient degree of accuracy and at low cost.

A manual-training school gives familiarity with mechanical tools and mathematical study gives familiarity with intellectual tools. In work with the manual tool the boy uses it for making something —he learns the principle on which it operates and the way to use it, by making something; if it is something useful it awakens a higher interest than does some fancy device. Likewise training of engineers in mathematics should be by doing something, by the solving of problems, by dealing with real rather than abstract conditions. Let this training be secured while applying mathematics to its normal and legitimate purpose as an auxiliary in the study of other branches.

In the teaching of mathematics for its own sake stress is apt to be laid upon the processes of deriving results rather than the real meaning of the results themselves. An engineer who uses logarithms has no more concern regarding their derivation than the ordinary user of the dictionary for finding the pronunciation of words has in their etymological derivation. The ability to reproduce demonstrations in higher mathematics from memory with the book shut is often not as important as it is to understand them with the book open. In general an engineer, who has occasion to use higher mathematics, will not be interested in evolving difficult equations, nor will he appeal to his memory, but with text-book or reference before him he will seek the things he wants to use. He should know where to find them and how to use them.

In emphasizing what a skilled mechanic can make with very ordinary tools, or the true engineer can accomplish with the parallelogram of forces and the rule of three, there is no intention of discrediting the value of fine equipments, either mechanical or mathematical, if there be the ability to use them.

Possibly the practical utility of mathematics may appear to be urged too strongly, particularly as the writer really believes in thorough mathematical training, but he has seen so many cases in which mathematical instruction has never been digested and assimilated, he has seen simple problems confused by unnecessary mathematical complications, he has seen men satisfied with results which are absurd because of some mathematical equations—sometimes quite unnecessary—which seem to obliterate common-sense perspective, and he recalls the new insight into mathematics which came through "Analytic Mechanics" under Professor S. W. Robinson at the Ohio State University, and "Problems in Mechanics," under Dr. Fabian Franklin at Johns Hopkins University, that he feels there is little danger in over-emphasizing the importance of concrete training in mathematical study.[2]

[2] Both of these teachers of mathematics had been trained as engineers and had practised the profession.

The practical questions which the discussion of this subject presents are these:

What mathematical subject-matter should be covered? And,

How should it be taught?

The first difficulty is that there is not, and can not be, a differentiation in technical education which is at all comparable with the wide range of occupations into which graduates will enter. We may assume, therefore, that we are considering the case of the average engineering student, taking for granted that options may be used by the best students for enabling them to take up the more advanced and difficult mathematics. Obviously the student should have enough mathematics to enable him to demonstrate the important engineering laws and formulas and to read intelligently mathematically written engineering literature. While only the relatively simple mathematics is commonly used by engineers, yet the ability to handle new problems with confidence requires a thorough understanding and appreciation of the significance of the mathematical and physical basis of the laws and phenomena he is to use. A man who is a thorough mathematician and knows how to apply his knowledge has a great advantage over the pure mathematician or the man without mathematical equipment. The better knowledge one has of the complex, the more certainty he has in applying the simple. A student should understand something of the power of the advanced mathematics and the field of its efficient application. Although he may not be expert in using it himself, he will know when to call for a mathematical expert.

An engineer of fairly wide experience remarked a short time ago: "The ordinary engineer does not use higher mathematics because he doesn't know how. He does not have the proper conception of the fundamental principles of the calculus because the subject has been taught by men whose ideals are those of pure mathematics."

If mathematics is something for engineers to use, let its use be taught to engineering students. After the fundamentals are learned, the students should attack the engineering problem at once and bring in mathematics as a means of solving it. Mathematics is often advocated for developing the reasoning powers and the ability to reason from cause to effect. There is danger, however, that mathematical machinery may make the mere process obscure the cause and the effect. Let them be foremost, with the process secondary or auxiliary to them.

The way mathematics is brought to bear on some engineering problems reminds one of the story of the old lady who greatly admired her preacher because he could take a simple text and make it so very complicated.

Old traditions have not wholly disappeared, the fear of degrading the pure science of mathematics by applying it to useful things still lingers—in influence, if not in precept. We must go further and adapt mathematics to engineering, not only in subject matter, but in method. A mathematical teacher with no patience for anything except mathematics will probably teach a kind of mathematics which has no connection with anything except mathematics. Engineering mathematics may be better taught as a part of engineering by an engineer, than as a part of mathematics by a pure mathematician. The maker of levels and transits who is expert in the construction of the instruments and an enthusiast over the accuracy of the surfaces, the excellence of the bearings, the near approach to perfection in the graduation and the general refinement and beauty of workmanship, may make a good in-

structor on instruments, but a poor teacher of civil engineering.

After all, it is not so much abstract courses as it is personal men with which we have to do, it is not mere knowledge of facts or facility in mathematical manipulation, but it is training. The young man is to be developed, his native individuality is to be the basis, he is to increase not only his knowledge, but his powers and the ability to use them. It is not mathematical skill so much as a mathematical sense, or mathematical common-sense, which is wanted. With pure mathematics as a science we have no quarrel—and little affiliation.

If you ask men who use engineering graduates what qualities they should possess, you will find that special prominence is given to "common-sense" and "the ability to do things." In mathematical training it is quality rather than quantity which is of first consequence. It should develop the facility for systematic and logical reasoning, thus furnishing a general method as well as a specific means of getting results.

We are concerned with applied mathematics. The ability to state a problem; to recognize the elements which enter into it; to see the whole problem without overlooking some important factor; to use good judgment as to the reliability or accuracy of the data or measurements which are involved; and, on the other hand, the ability to interpret the result; to recognize its physical significance; to get a common-sense perspective view of its meaning and the consequences which may follow; to note the bearing of the various data upon the final result; to determine what changes in original conditions may change a bad result into one which is practical and efficient—such abilities as these are of a higher order than the ability to take a stated problem and work out the answer. It may be urged that all this is not strictly mathematics. But it is just this sort of judgment and insight which makes mathematics really useful, and without them there is danger that they may be neither safe nor sane.

The trend in education is to a closer relation to the affairs of life. Science and applied science, scientific and engineering laboratories, are overcoming old ideas and prejudices. Modern engineering development brings its transforming influence to bear upon education as well as the utilities of modern life. The engineering school has had a phenomenal growth within the lifetime of the recent graduate—a growth in ideals and methods as well as students and equipment. It has raised and agitated broad questions as to what constitutes efficient education for producing effective men. It has aimed to combine not only the abstract with the concrete, the lecture room with the laboratory, and the scientific experiment with the practical test; but it has sought by various means to bring the work of the school into close relation with active professional and commercial practise. It has a definiteness of aim and purpose which other educational courses are apt to lack. It sets out to produce men who can deal with forces and materials according to scientific principles. It develops men whose contact with physical facts and natural laws at first hand and whose ability to reason logically fit them for dealing with new problems. The training which fits men for handling engineering problems is the kind that is needed for dealing with the organization and directing of men. The sphere of the engineer is one the scope of which will continue to increase as engineering education and training produce men whose contact with natural phenomena gives them an inherent respect for facts as their premises, who are able to think straight to logical

and common-sense conclusions, who have an equipment of technical knowledge and who can produce results.

In discussing the teaching of mathematics to engineers, we should emphasize not the mathematics nor the engineers, but the teaching. Aside from the imparting of knowledge and technical ability, the teaching of mathematics gives opportunity for training in the use of logical methods and in the drawing of intelligent conclusions from unorganized data which will make efficient men, whether they follow pure engineering, or semi-technical, or business pursuits. Such teaching does not come from the text-book; it must be personal—it comes from the teacher. He must be in sympathy with engineering work and have a just appreciation of its problems and its methods. He must be imbued with the spirit and the ideals of the engineer.

Chas. F. Scott

THE POINT OF VIEW IN TEACHING ENGINEERING MATHEMATICS[1]

I hardly know why I should have been asked to address you at this conference. Possibly, however, the fact that I am a civil engineer by profession, without having been permitted ever to practise this profession, and the additional fact that I have been a professional teacher of mathematical physics, without having been permitted to continue in this work, have led your committee to think that I might furnish a conspicuous illustration of the failures to which colleges and universities may lead in these lines of endeavor.

Having listened attentively to the three formal papers just read, I find it essential to revise my program and instead of following similar lines to those of the preceding speakers, it seems essential to take direct issue with them. This I am disposed to do, not so much because I differ wholly from the views they have set forth, as because it seems necessary to have other sides of the questions they have discussed represented. The preceding speakers appear to me to have taken themselves somewhat too seriously. This is a general fault of both theoretical and practical educationalists. My own experience leads me to conclude that in educational affairs the teacher, the school, the college and the university play a much less important rôle than we commonly suppose. In fact, I have reached the provisional conclusion that the majority of our students turn out fairly well in the world not so much by reason of the academic instruction they receive as in spite of it.

My impression also is that in taking ourselves too seriously as teachers of one subject or another, we have, as a rule, quite underestimated the magnitude and the difficulty of the psychological problems with which we have to deal. We have, as a rule, quite overestimated the capacity of our average student, and have thus usually expected too much from him. It is, of course, desirable to set our ideal high and try to rise to an elevated intellectual level; but in doing so we have commonly neglected the influence of heredity as well as of environment. I am inclined to think Dr. Holmes was right when he said that it is essential in the generation of a gentleman to begin four hundred years before he is born. So also is it necessary, if we wish to develop a student into a first-class scholar, to begin back some generations before we take up the formal work of training in our colleges or schools of engineering. It is an important fact, also too commonly over-

[1] Extempore remarks before Sections A and D of the American Association for the Advancement of Science and the Chicago Section of the American Mathematical Society, at the Chicago meeting, December 30, 1907.

looked, that the fundamental ideas involved in the mathematics and in the mathematical physics essential to the preliminary training of a prospective engineer are far more difficult of comprehension than we are wont to suppose. As a rule, I think we begin our elementary mathematics somewhat too early for the average mind. The result is that our students acquire a mere literary knowledge of the subject without grasping the basic ideas essential to clear thought and especially essential to applications. I am going to give you some illustrations of this fact. They will show how difficult it is for the average mind to attain a proper understanding of mathematico-physical concepts. The difficulties here are much the same as the difficulties of grammar. As you know, children learn to speak, and often speak very well, long before they know anything of formal grammar, and this is the natural mode of development, for the logic and subtleties of grammar can be appreciated only by rather mature minds.

But if the concepts which belong to the study of language and of grammar are rather formidable, those which belong to the higher mathematics and mathematical physics are profoundly more difficult of adequate comprehension. Let me illustrate this point by a citation from experience furnished by the case of a graduate from one of our universities who presented himself to me a few years ago, while I was dean of a graduate school of Columbia University, as a candidate for a higher degree in mathematical physics. This student had studied mechanics and had attained a degree in engineering. In order to learn something of the breadth and depth of his knowledge, I asked him what it is that makes the trolley car run after the current is cut off. He answered, "It is the force of the momentum of the power of the energy of the car." There is no reason to suppose that he had not received good mathematical and physical training, and yet it is plain from the answer he gave me that he knew next to nothing of the meaning of the terms he used. I may cite another case of a successful practising engineer, who was a pupil of no less authorities in mechanics and engineering than Lord Kelvin and Rankine. This man wrote me a letter in which he sought to convince me that Newton and his followers are all wrong with regard to the parallelogram of impulses. "Thus," he said in his letter, "if a particle start out from a given point under the simultaneous action of two impulses, it will not move in the parallelogram of the impulses, but it will move in a tautochronous, brachistochronic, plane catenary curve of a resilient character."

These illustrations show how extremely difficult it is to master the fundamental ideas which belong to a great science; and the difficulties are so great that I am disposed to excuse, or at any rate palliate, the blunders made by our average student. He is, in fact, with all his blunders, not very far behind many of his teachers, for it is not uncommon for them to use in their lectures and text-books words not at all free from ambiguity. Witness, in fact, the loose use of such words as force, power, pressure, stress, and strain in some of the best text-books and treatises of the nineteenth century. The word "power," for example, is often used in two radically different senses in the same sentence.

These difficulties and ambiguities lead me to suggest, in opposition to the precepts laid down by a previous speaker, that we may well consider the desirability of printing mathematical books free from demonstrations but containing plain statements of facts. I have used such books myself and am disposed to think they are amongst

the best books we may place in the hands of a student. The simple fact is that we do not follow a logical order of development in acquiring knowledge. We proceed rather by the method of "trial and error," and we often find out the facts with regard to an item of learning long before we become aware of the principle involved.

Hence I think the reason why few of our engineers know much about the formalities of mathematics and mathematical physics after they get through college is plain enough. They are driven over so many subjects during the four years of their college life that they have little or no time for reflection. This latter must come later in life when the mind has developed a sufficient degree of maturity to appreciate the more recondite principles which lie at the foundation of all the higher learning. This fact is well illustrated also by the case of our friends, the humanists, who have, as you know, for a long time proposed the study of geometry for "mental discipline." As a matter of fact, those who have acquired anything like a grasp of geometrical principles know that very few students of Euclidean geometry acquire anything like an adequate appreciation of the ideas involved, and it is only in the rarest instances that these students pursue the subject after leaving college.

I have not much sympathy with the engineers who would like to have their own kind of mathematics, and I am not disposed to commend very highly the works on calculus and other branches of pure mathematics designed especially for engineers. On the other hand, our modern mathematicians have generally failed to understand the needs of the engineer. Our more recent type of mathematician has devoted himself too largely to the refined questions of convergence and divergence of series and of existence theorems to properly equip him for the numerous and important applications which the ideal engineer should be able to make of his mathematical knowledge. The modern mathematician seems prone to make the engineer with some degree of mathematical talent afraid of himself. I have met some students whose early training had filled them with caution to such a degree that they would not use infinite series for fear that a divergent one might be encountered. It is known, however, as a matter of fact, that most series essential in the applications of mathematics to mathematical physics are safe in this regard, and one of the best ways for the elementary student to learn of the degree of convergence is to apply numerical computation to these series.

This leads me to say a few words concerning numerical computations, in which very few engineers and still fewer mathematicians show any degree of proficiency. It seems to me this is one of the most lamentable defects of our elementary teaching in mathematics, though here as elsewhere the intrinsic difficulties are much greater than we commonly suppose. This fact is in evidence at almost every meeting of our scientific societies, for it oftenest happens that the author of a paper involving numerical calculation will talk of the decimals involved instead of the significant figures. Thus, he will say, "this result is correct to five places of decimals," when he should say, "this result is correct to a specified number of significant figures," the latter form of expression being requisite to indicate the degree of precision attained. There is a grave defect in our elementary teaching in these matters; but it arises from the fact that almost none of our teachers of elementary mathematics are qualified to understand the refinements and the difficulties of precision in compu-

tation. Thus, it often happens that students will give results to five or seven significant figures when the data do not justify any such apparent precision.

To correct these evils we must have a convention of mathematicians, engineers and professional computers who will show authors how to produce elementary text-books giving adequate attention to these matters.

As regards numerical computation, there is in general need of more practise, since it is through the concrete that we learn of the abstract and the fundamental. No important formula in any text-book or treatise should go without an appropriate illustrative numerical example.

I would like to take advantage of this occasion to express a hope with regard to the future of our country and to the possibility of development which may come through suitable cooperation between mathematicians and engineers. Nothing delights me more than to attend a meeting of this kind where mathematicians and engineers have come together. It is an auspicious sign of the times. It is one of the results I have been looking forward to for the past thirty or forty years. Some of us here are old enough to have lived in two epochs, namely, the pre-scientific and the present epoch. We can remember a time when engineers could not have got a hearing such as they have to-day. The history of their rise and development, at least in this country, is well known to some of us. It dates back to a time only about forty years ago. During this time the engineers have fought their way forward to the position now accorded them in contemporary society. They have won a place in public esteem without which it would have been impossible to hold such a conference as we are holding to-day. This esteem has been won in spite of much opposition, coming especially from the older academic institutions; but now having attained adequate recognition especially as practising engineers, we have a much higher duty to perform, and this I trust we shall be able to meet adequately through cooperation with our friends the pure mathematicians. I know of no work more important to the general advancement of mathematico-physical science than that which may lead to the development of mathematical physicists, men who possess at once good mathematical knowledge and correspondingly adequate equipment in physical science. Here is a field greatly in need of concentrated effort and of adequate appreciation. It is a lamentable fact that while we can easily develop pure mathematicians of a high order and experimental physicists of an equally high order, it seems very difficult for us to develop minds possessing both qualities. To a large extent I think the development of pure mathematics in the future will depend, as in the past, on the stimulus furnished by mathematico-physical ideas; and in like manner success in the development of mathematical physics will depend equally in the future on mathematical ability of the highest order. In this line of work we Americans have not done our full duty, and it behooves us as mathematicians and engineers, now that we have got together on the plane of mutual interest, to give attention to this important field of work.

The French engineers led by Navier and followed by Lamé, Clapyron, and especially by the "dean of elasticians," Barré de Saint-Venant, have contributed to science the most important branch of mathematical physics, namely, what is commonly called the theory of elasticity. This is superbly difficult in its purely mathematical aspects and exquisitely beautiful in its physical aspects, and it stands as a splendid example of the possibilities which

may result from adequate cooperation between mathematicians and engineers.

The chief difficulty in the way of developing mathematical physicists appears to lie in the inadequate appreciation of this type of work by contemporary society. Pure mathematics has a prestige of more than twenty centuries behind it, and the practical work of the engineer appeals even to the dullest of intellects; but we have failed thus far, in this country especially, to adequately esteem the worker in the intermediate field. We must look to it that more attention is given to this field in our colleges and universities. Every university should have two or three men eminent in mathematical physics as well as two or three men eminent in pure mathematics. Thus, while I would not advocate the pursuit of pure mathematics or the pursuit of practical engineering less, I would urge the pursuit of mathematical physics more. It is only by the cultivation of this branch of study and investigation that we can keep alive the sources of engineering knowledge. Important and indispensable as the practical work of the engineer is, the cultivation of investigation and discovery in his science is still more important and indispensable. Hence I would urge that when the more pressing questions of elementary instruction in mathematics and engineering have been adjusted, we give attention to the more inspiring and more important questions of the clarification and enlargement of the fundamental ideas of our sciences.

R. S. Woodward

THE CHICAGO ACADEMY OF SCIENCES[1]

In his historical sketch of the academy, published in 1902, Mr. W. K. Higley, late secretary of the academy, divides the history of the institution into three periods, first, that preceding the fire of 1871; second, that between the time of the fire and the erection of the present building in Lincoln Park, and third, the period dating from the occupancy of these new quarters. It is often of interest and value to cast a retrospective glance over a period of years in the history of an institution, in order that a clear idea may be obtained of the value of the operations. It is now thirteen and a half years since the building was first occupied and the intervening years have witnessed a steady growth in the collections and also in the interest of the academy's work among the citizens of the community and of the city. The collections which were turned over to the curator in July, 1894, were comparatively small in number, although containing some very interesting and valuable material. The records show an aggregation of about 55,000 specimens on this date. In the thirteen and a half years this number has been increased fourfold; the number of specimens in the museum January 1, 1908, being 226,781, or an increase of 171,781 specimens. It must be remembered that the majority of these additions were presented by the owners or collectors, as there has been no fund for the purchase of specimens. It must not be forgotten, however, that several members of the academy, like our deceased patron, Mr. George H. Laflin, have from time to time given money for the purchase of material, but the entire amount spent for such purposes has not exceeded $5,000. A part of the collections have been secured by the museum staff while on their vacations.

An analysis of the additions shows that three departments head the list in the number of additions:

Mollusca	89,757
Insects	33,914
Paleontology	21,145

The first named contains several types, a larger number of cotypes and a very extensive series of autotypes and locotypes, as well as many rare species and development series. The same is true of the fossil collection and to a less degree of the insect collection. The

[1] Extracted from the annual report of the secretary.

total collection of Mollusca now numbers over 140,000 specimens.

It is interesting to note that thirteen years ago the main museum floor was supplied with cases which were filled with very indifferent specimens, poorly installed. At the present time three floors are crowded with cases, which are filled with much excellent material, some of which is as good as can be obtained. The old strictly taxonomic system of installation has been replaced by one of a more or less ecological character, which is calculated to educate the visitor along nature-study lines. For this purpose eight large groups and forty-five smaller ones have been constructed, showing to a greater or less degree some of the interesting habits of native animals. The taxidermic work has all been accomplished by Mr. Frank M. Woodruff, with the rarely occasional assistance of an extra taxidermist in large group work. The taxidermist has also filled the positions of ornithologist and photographer, having prepared over 2,600 slides, negatives, etc., in the past seven years. The minerals, rocks, fossils and physiographic collections have been likewise arranged with the educational idea in view.

The library has shown comparatively as large an increase as the museum. Beginning in 1894 with 8,381 books and pamphlets, it has increased in 1907 to 26,821 books and pamphlets, or a growth of 18,440 in thirteen and a half years. It is also noteworthy that the exchange list of foreign and domestic societies has grown from 120 in 1894 to 542 in 1907, or an increase of 422. This increase has been made possible by the continued issue of the publications of the Natural History Survey. The gratitude of the academy is due to the many foreign and domestic societies who have so generously continued sending their large and valuable publications when those of the academy have been so few and their issue so irregular.

The satisfactory labeling and cataloguing of a museum is a subject of no small magnitude and the academy was not able until the year 1900 to secure the assistance and material necessary for the successful carrying on of this important work. At this time a printing outfit was secured and very satisfactory work has been carried on by this department in the eight years of its existence, during which time 20,433 labels have been printed, aggregating 100,000 impressions. In 1903 a new set of registration books was opened, and a card catalogue of the museum begun. During the four intervening years over 26,000 entries have been made. In comparing the work of this department with that of other institutions it must be remembered that it has all been accomplished by one assistant, a lady, whose duties in addition are to send all acknowledgments, typewrite all letters and manuscripts for publication, and attend to other office duties, besides assisting in the care of the library. She also learned to do the printing when that system superseded the old hand-written label.

The value of a museum of natural history is oftentimes measured by the attendance, although a large attendance is frequently due to the advantageous location of a museum, rather than to its interest for the public. It is interesting to note that if classed by its attendance the academy would stand well up among the larger museums of the United States. For a number of years the attendance was accurately kept at the Academy of Sciences, and during five years the smallest attendance was 245,214 and the largest 413,390, or an average of 338,352. It is believed that more than 4,567,000 people have visited the museum during the thirteen and a half years of its occupancy of the building in Lincoln Park. A comparison of the attendance of the larger institutions with that of the academy is significant:

American Museum of Natural History, New York City	467,133
U. S. National Museum and Smithsonian Institution, Washington	360,547
Chicago Academy of Sciences	338,352
Field Museum of Natural History, Chicago	254,516
Brooklyn Institute Museum, including Children's Museum	229,025

A notable feature of the academy's work has been the use of the museum and its staff in

supplementing the nature work of the public schools. In addition to the usual classes which visit the museum as a special holiday occasion, several schools have devised a plan by which the museum exercise becomes a recognized part of the school work and counts in points as does any other part of the curriculum. Classes are taken to the museum in charge of the teachers who provide them with question blanks or direction sheets and allow the pupils a certain length of time for the completion of the work. The notable feature of this class of work is the discipline which prevails.

Several of the high school teachers have given Saturday morning lectures on bird study to their classes, in the lecture hall of the academy and for a time a series of lectures was given for children.

During two years a course of lectures on biology was given for the benefit of teachers interested in nature work. Laboratory and study facilities have also been freely placed at the disposal of those teachers who wished to carry on more extended studies.

Some of the museum collections have been largely used for loan purposes and much of the duplicate material has been freely placed at the disposal of those schools or teachers who expressed a desire to use a small hand collection in the class-room. Lantern slides and other photographic material have also been freely loaned for educational purposes.

It is noteworthy that a large per cent. of the museum visitors are of the more intelligent class of people, who visit the museum from a higher motive than that of mere curiosity, although it is unquestionably true that many visitors are of this latter class.

Since 1895 the academy has conducted yearly a series of popular lectures in addition to its regular monthly meetings. The effort has been made in these lectures to popularize the various branches of science and still keep them up to the highest standard of excellence. These lectures have been given in courses of from six to twelve each, two or three courses being given in a year. Two hundred and seventy-eight such lectures have been given during the past thirteen and a half years, at which the total attendance was 43,856. One hundred and twenty-five regular meetings have been held, at which 6,765 members and their friends listened to the reading and discussion of scientific papers. This phase of the academy's work has proved of great educational value.

A portion of the time of the museum staff has been consumed in the identification of material for other institutions, or for scientific workers, and during the past four years nearly 35,000 specimens have been thus cared for.

In making a retrospective study of an institution much depends upon the resources available in estimating the value of the work accomplished, and the results seem large or small as the income is small or large. For the past thirteen and a half years the only assured income for maintenance has been $5,000 per year, which is given by the commissioners of Lincoln Park for the privilege of having the museum in the park and free to the people at all times. In addition to providing this sum of money the commissioners heat, light and clean the building. This sum of $5,000 has been variously augmented through the generosity of friends of the academy and by the annual membership fees. The income has fluctuated, being the lowest in 1898, when it was $5,321.60, and the highest in 1895, when it rose to $14,190.48. During the thirteen years under consideration the total income has been $96,024.07, or a yearly average of $7,386.46. When compared with the princely incomes of such institutions as the American Museum in New York, the Field Museum in Chicago, or even the smaller Public Museum in Milwaukee, with its nearly $30,000 yearly income, the resources of the academy seem small indeed and it is remarkable that it has been possible to accomplish even the small amount of work herein detailed, with such scanty resources. It is encouraging to reflect that, with the additional endowment provided by the Moses Wilner Bequest, the yearly income will soon amount to $10,000.

In closing this very brief summary of the work accomplished during the past thirteen

years, the fact should be emphasized that it is not so much the number of specimens which have been received nor the amount of detail work which has been accomplished which determines the success or failure of an institution, but rather the impression which may have been made upon the community in inciting to higher ideals of life, and the quality of the contribution to the advancement of science and education which has been made.

FRANK C. BAKER,
Acting Secretary

THE LLOYD LIBRARY AND MUSEUM

THIS institution is legally a stock company, the stock being owned and the institution supported by Curtis G. and John Uri Lloyd, of Cincinnati, Ohio. Mr. C. G. Lloyd has erected the buildings and supports the botanical section, and Professor John Uri Lloyd supports the pharmaceutical department. The buildings and contents are transferred to the stock company, and funds are provided for its continuance when the life work of its builders is finished. It will never be sold, and will always be a free and public institution for the benefit of science.

Building No. 1 was erected by C. G. Lloyd in 1902, and was designed to contain both the books and the specimens, the two upper floors being devoted to the books and the lower floor to the specimens. During the short time that has intervened the library has increased so rapidly that the building is inadequate for its purposes, and during the past winter a new building has been erected to be devoted exclusively to the library. The old building, now known as the Lloyd Museum, will contain the herbarium and the mycological collection. The herbarium of pressed plants is estimated at about thirty thousand specimens, chiefly obtained by exchange by C. G. Lloyd during his earlier years. The mycological department contains many thousand dried specimens of fungi, particularly of the Gastromycetes, estimated at not less than five thousand different collections. There are more specimens of this family ten times over than in all the other museums of the world combined.

Building No. 2 was erected in the winter of 1907 and 1908. It is four stories, 22½ by 72 feet. It is devoted exclusively to botany and pharmacy (with a section on eclectic medicine), and contains a collection of books among the largest on these subjects. The volumes have not been counted, but some idea of the number may be obtained from the following statistics: There are 6,253 linear feet of shelving, and the books now occupy 2,600 linear feet of this space. As a shelf is found to hold on the average 429 books to every 50 linear feet, the estimated number is 22,308 volumes. Cases have been placed in the upper floor, but the other three floors have only wall shelves, with provision made for floor cases in future as the needs of the library may require. When completely filled with shelving the library has a capacity of 11,413 linear feet, sufficient to shelve 98,000 volumes. If the collection of books continues to increase as it has in the past five or six years, the full capacity of this library will be taken in the next twenty years. The founders propose to make the Lloyd Library in time a practically complete library of its subjects.

LEHIGH UNIVERSITY AND THE UNIVERSITY OF LIVERPOOL

On July 3, the University of Liverpool, acting on behalf of Lehigh University, under letters of attorney duly authorizing the act, conferred on Horace Field Parshall, the well-known electrical engineer, of London, the honorary degree of master of science. Mr. Parshall is an American, a graduate of the electrical course at Lehigh University of the year '87.

The letter of Vice Chancellor Dale, of the University of Liverpool, to Dr. Henry S. Drinker, president of Lehigh University, accepting this duty, is pleasing in its hearty expression of international comity. He says:

"The Council and Senate of this University have agreed to act on the suggestions that you make, and to confer formally on Mr. Parshall the honorary degree that has been awarded to him by the University over which you preside.

When the hood and diploma have reached us I will then arrange with Mr. Parshall for his formal admission to the degree.

"So far as I am aware no precedent or parallel for such an act can be found in the history of British Universities. But it is our business to make precedents as well as to follow them, and we trust that in so doing our act will be regarded as an expression of fellowship and sympathy with kindred institutions carrying on similar work, established for similar services, and bound to us by many ties."

The degree was conferred at a special "congregation" of the University of Liverpool, attended by the United States consul general and many distinguished guests. The dean of the faculty of science presented Mr. Parshall for admission to the degree, and the vice chancellor duly admitted him.

SCIENTIFIC NOTES AND NEWS

Governor Guild, of Massachusetts, has appointed a State Conservation Commission to act in cooperation with the National Conservation Commission named by President Roosevelt after the recent conference on resources. It is composed of Professor F. W. Rane, state forester, chairman; Professor George F. Swain, of the Massachusetts Institute of Technology, and President Kenyon L. Butterfield, of the Massachusetts Agricultural College, Amherst.

Professor Wm. T. Sedgwick, of the Massachusetts Institute of Technology, has been appointed one of a commission of four to investigate the causes of typhoid fever in Pittsburgh, by Mayor Guthrie, of that city. The expenses of the investigation will be paid out of $10,000 appropriated by the Russell Sage Foundation. He was also offered by Mayor Hibbard, but felt obliged to decline, one of the vacancies in the Board of Health.

Dr. L. O. Howard, chief of the Bureau of Entomology of the U. S. Department of Agriculture, and permanent secretary of the American Association for the Advancement of Science, has been made an honorary member of the Société Nationale d'Acclimatation de France.

Professor Holland, K.C., has been elected a corresponding member of the "Reale Academia delle Scienze dell'Istituto" of Bologna, as also an honorary member of the "Reale Academia di Scienze Lettere ed Arti" of Padua.

At the annual general meeting of the Faraday Society, held in London, on June 23, Sir Oliver Lodge was elected president and the following vice-presidents were chosen: G. T. Beilby, R. A. Hadfield, Professor W. Hittorf, Professor A. K. Huntington, Lord Rayleigh, Professor A. Schuster and Professor J. J. Thomson.

The council of the Royal Society of Edinburgh has awarded the Neill prize for the triennial period 1904–7 to Mr. Frank J. Cole, lecturer on zoology, University College, Reading, for his papers entitled "A Monograph on the General Morphology of the Myxinoid Fishes, based on a Study of Myxine," published in the "Transactions" of the society, regard being also paid to Mr. Cole's other valuable contributions to the anatomy and morphology of fishes.

Dr. W. J. Holland, the director of the Carnegie Museum, has returned after three months' absence in Europe during which he installed in Berlin and in Paris casts of Diplodocus Carnegiei which were presented respectively to the emperor of Germany and the president of the French Republic. The latter on June 15 conferred upon Dr. Holland the order of Officier de la Légion d'Honneur "in recognition of his services to the science of paleontology," and upon his assistant, Mr. A. S. Coggeshall, he bestowed the order of Officier de l'Instruction Publique. On the evening of the same day a banquet in honor of Dr. Holland was given by the professors of the National Museum, which was attended by many of the leading scientific men of Paris. Addresses were made by M. Paul Doumer, M. Bayet, assistant minister of public instruction, Professor Edmond Perrier, Professor Gréhant, Professor Becquerel and

others. On the evening of June 14, Dr. Holland delivered an address in the French language on the work of Mr. Andrew Carnegie on behalf of science, before an audience of fifteen hundred people assembled in the Grand Amphitheatre at the Jardin des Plantes. An abstract will shortly appear in the *Revue Scientifique*.

THE Smithsonian seat in the Zoological Station at Naples, Italy, has been assigned for a period of from four to six months between October 1, 1908, and June 1, 1909, to Harold S. Colton, Ph.D., of the University of Pennsylvania.

HERBERT PARLIN JOHNSON, Ph.D. (Chicago), associate professor of bacteriology in St. Louis University, will return to his work in October much improved in health by two years leave of absence.

PROFESSOR CHARLES JAMES, of New Hampshire College, is at present in Norway collecting a supply of the rare minerals for a continuation of his work on the rare earths. He has already secured several hundred pounds of euxenite and other minerals, which he will work up in his private laboratory at Kettering, England, and bring the crude oxides with him on his return to America. He has already about one hundred and fifty grams of lutecium and about fifty grams of thulium on hand, but is desirous of largely increasing the amount of these substances, as well as his already extensive supply of erbium compounds, in order that they may be separated in that special degree of purity which can only be secured when working with large quantities.

WE regret to record the following deaths: Professor J. V. Barbosa du Bocage, director of the Zoological Institute, at Lisbon, at the age of eighty-four; Dr. Luiz Cruls, director of the Observatory of Rio de Janeiro; Dr. Heinrich Wilhelm Struve, known for his work in chemistry, at Tiflis, at the age of eighty-five years; and Dr. Erich Ladenburg, docent for physics at Berlin, at the age of twenty-nine years.

A MOVEMENT is on foot to organize the Physical Section of the American Chemical Society as a Division of General and Physical Chemistry of that society as has been done by the industrial chemists and chemical engineers. The Physical Section at New Haven, under the chairmanship of Dr. F. K. Cameron, had an unusually extensive program consisting of some forty-eight papers. Greetings were received from Arrhenius, Emil Fischer, Roscoe, Ramsay, van't Hoff, Julius Thomsen, Lunge and von Baeyer, and papers were sent for the meeting by Svante Arrhenius on "Agglutination and Coagulation" and two papers by Emil Fischer on "Polypeptides" and on "Micropolarization."

IN the new tower that is being built in place of the old stone tower at Blue Hill Observatory, the Massachusetts Institute of Technology will install its new seismograph. The tower is being made moisture-proof as far as is possible. When the seismograph is installed, it will be under the charge of the observatory force.

PURSUANT to a recent decree of the government of Peru issued by President Pardo, the time of the seventy-fifth meridian west of Greenwich was on July 28 adopted as the national standard time for the whole of Peru. As pointed out by Professor Todd, in his address to the Geographical Society of Lima last August, the advantages of standard time would be specially marked as the proposed meridian is only a few minutes from that of Lima, and runs almost exactly through the middle of the country. Rarely is a country more favorably placed geographically for adoption of standard time, which has everywhere proved a great benefit in greater facility of commercial despatches, as well as precise regulation of internal affairs and international intercourse. All timepieces throughout Peru will now coincide with those in the United States where eastern time is kept. Peru is the first South American republic to adopt the world standard.

IN connection with the celebration of the tercentenary of the birth of Evangelista Torricelli, an exhibition will be held at Faenza

from August 15 to October 15. Included in the program, and associated with an international section for physical apparatus, in celebration of Torricelli a prize of 2,000 lire is offered for an instrument in connection with meteorology or physics of the earth. The instrument must be exhibited, and show real novelty, either in its principle or in its application of a principle already known. For further particulars application should be made to Dr. W. N. Shaw, F.R.S., Meteorological Office, 63 Victoria Street, London, S.W.

Nature says: "At the General Conference on Weights and Measures, held at Paris in October last, a resolution was unanimously passed urging the universal adoption of a metric carat of 200 milligrams as the standard of weight for diamonds and precious stones. This proposal, which received a large measure of support on the continent, especially in France, Germany, Spain and Belgium, was brought under the notice of the principal diamond dealers in this country by the Board of Trade early in the present year, but it has not met with a favorable reception from the trade, and unless the proposed new standard is generally adopted abroad it is unlikely that any further action in the matter will be taken by the government. The French Ministry is now introducing a bill to legalize the 'metric carat' of 200 milligrams in that country, and to prohibit the use of the word carat to designate any other weight. A recent resolution of the Bombay Chamber of Commerce shows that the proposal for an international standard carat is receiving favorable consideration in India."

Governor Hughes has signed a bill passed by the New York legislature declaring tuberculosis to be an infectious and communicable disease, dangerous to the public health, and providing for the reporting of all cases to the local health authorities. According to the *Journal of the American Medical Association*, it provides for the free examination of sputum by the health authorities, for the protection of the registration records from public inspection, and for the disinfection and renovation of the premises after the death of a person having tuberculosis. The occupation of premises vacated by a tuberculous person is prohibited until the directions of the health department providing for disinfection and renovation have been complied with. The bill was lengthy and some of the important sections follow: Section 8 makes it the duty of the physician to take all reasonable precautions for the protection of individuals occupying the same house with any one having tuberculosis. If there be no physician in charge of such patient, this section provides that this duty devolves on the health officer. Section 9 provides that the attending physician shall report to the health officer, on blanks to be furnished for this purpose by said officer, a complete statement of the procedure and precautions taken by him in a case of tuberculosis coming to his notice, and the physician shall receive for his services a fee of $1. If the physician does not desire to take these preventive measures and make this report, the duties therein stated shall devolve on the health officer, who shall receive said fee. The health officer is required to keep on hand and furnish suitable supplies and literature to physicians to aid in preventing the infection of others. Section 10 provides a penalty for the failure of physicians or others to execute the duties imposed by this act, or for making false reports, the penalty not to exceed $100, or six months in prison or both. Section 11 provides for the reporting by physicians of the recovery of the tuberculosis patients, and for their release thereon under the provisions of the law. Section 12 makes violation of any section of this act a misdemeanor, punishable by a fine of not less than $5 or more than $50.

A bulletin of the Forest Service calls attention to the fact that the supply of dogwood and persimmon shuttles in the southern states is nearly exhausted. This statement will not appear significant to the average man when he first hears it. But when he is told that the entire supply of shuttles, bobbins and spindles used in the cotton and woolen mills in all parts of the country is furnished by the dogwood and persimmon growing in the

southern states, the seriousness of the situation is apparent. The textile mills of the country represent a capitalization of nearly a billion dollars, and bobbins, shuttles and spindles are just as necessary parts of these mills as the throttle is to the locomotive. Fortunately the shuttle manufacturers have found another source of supply in the dogwood stands in the far northwest part of the country. Two large companies manufacturing spindles, shuttles and bobbins have erected plants in the Cascades in Oregon, whose dogwood forests are the greatest in the world, the tree often attaining a height of 75 feet and a diameter of one to two feet. The southern dogwood is rarely more than 6 inches in diameter. Extensive stands of dogwood are also found in California and Washington. Up to the present time, lumber users in the Pacific northwest have found dogwood valueless except for fuel, and its utilization for the manufacture of shuttles will bring about a considerable increase in stumpage values of this tree. These companies, at their Oregon plants, will not only manufacture the articles named, but will utilize every part of the tree, turning to account the waste wood and producing such by-products as pyroligneous acid, acetic acid, protacetate of iron, acetate of lime, methylated spirits, solvent naphtha, wood tar, wood pitch, and various forms of charcoal. Dogwood is indispensable in the manufacture of shuttles, bobbins and spindles, because it is the only wood which takes a high polish and wears perfectly smooth by friction under water. The discovery of the adaptability of the Pacific dogwood, however, has not aided the eastern manufacturers, and they have been obliged to look for substitutes nearer home. The most promising of these are mesquite and tupelo gum. The wood of the mesquite is heavy and very hard, close grained, and has a compact structure. It is probable that it would be eminently adapted for the manufacture of shuttle blocks, as it appears to have all the requisite qualities of weight, hardness, and susceptibility to a high smooth polish. Already it has proved well fitted for the manufacture of spools and bobbins for which white birch is now so largely used. The tupelo gum is medium hard and heavy, and has a compact fibrous structure. It has not yet been utilized to much extent in the textile industries, though it is quite probable it will play an important part in the future, since it combines with several necessary qualities the exacting property of wearing smooth by friction.

UNIVERSITY AND EDUCATIONAL NEWS

THE University of Illinois, on July 3, let a contract for the erection of the physics building, for which the last legislature made an appropriation of $250,000. The building is to be of brick with Bedford stone trimmings, and is to be fireproof. Its length is 178 feet and depth 125 feet. The first floor is rectangular, and the three upper floors are U-shaped. The space between the wings on the first floor is used for the large lecture rooms, in which overhead lighting is used. In addition to the large laboratories and class-rooms for the regular undergraduate courses, the building contains twenty-four small laboratories specially arranged for research students. The university was fortunate in letting its contract at a time of lower prices, so that funds are available for satisfactory furnishing and equipment of the building. The building is to be completed in the summer of 1909. A contract has also been let for an addition to the natural history building, for which the last legislature appropriated $150,000.

A SCHOOL of journalism has been organized in the University of Missouri, with Professor Walter Williams as dean. As a laboratory feature it has the *University Missourian*, a small but well-balanced daily newspaper, upon which the work will be done, under the direction of experienced newspapermen, by the students of the school. Courses will be given in the history and principles of journalism, in newspaper administration, in illustration, in the libel law, in news-gathering, in reporting, in editorial writing, in office equipment, and in other purely professional branches. In addition, courses will be given in English

composition and literature, history, government, sociology, economics and other academic branches desirable for preparation for journalism. The course will cover four years, but a combined course will be offered, in which both the work in the College of Arts and Science (the academic department) and the School of Journalism can be taken in five years. Tuition in this school, as in all departments of the university, is free.

Commencing in 1909 students entering the College of Medicine of Syracuse University must have satisfactorily completed one full year, and on and after October, 1910, two full years in a science or arts course in a college recognized by the regents of the State of New York and in that course and in their preparation for it a competent course in physics, chemistry, Latin, one modern language and biology must be included. The equivalent of this requirement, that is, evidence of having passed college examinations for admission to the sophomore or junior class in a recognized college by a student possessed of a medical student certificate from the State Educational Department, will be accepted. Hereafter all chemistry except applied chemistry will be taught in the new Bowne Chemical Laboratory of the College of Liberal Arts instead of in the College of Medicine as heretofore.

Professor C. H. Eigenmann, professor of zoology, has been appointed dean of the Graduate School of Indiana University.

Dr. Frank D. Adams, Logan professor of geology, has been appointed dean of the faculty of applied science at McGill University.

Mr. H. F. Dawes, M.A., who has held the Wollaston research studentship at Gonville and Caius College, Cambridge, for the past two years, has been appointed lecturer in physics in his alma mater, the University of Toronto. Mr. C. S. Wright, B.A., of the University of Toronto, has been awarded the Wollaston research studentship in physics by Gonville and Caius College, Cambridge, England. This studentship has an annual value of £120, is tenable for two years, and is open to all graduates of British and American universities.

Appointments and promotions at the Massachusetts Institute of Technology have been made as follows: Arthur A. Blanchard, assistant professor of inorganic chemistry; Alpheus G. Woodman, assistant professor of food analysis; Ervin Kenison and Harry C. Bradley, assistant professors of drawing and descriptive geometry; Hervey W. Shimer, assistant professor of paleontology; Joseph C. Riley and Charles W. Berry, assistant professors of mechanical engineering; Harrison W. Hayward, assistant professor of applied mechanics.

The following changes have been made in the faculty and curriculum of the College of Medicine, Syracuse University: Frank P. Knowlton, A.M., M.D., associate professor of physiology, to be professor; H. S. Steensland, B.S., M.D., associate professor of pathology and bacteriology, to be professor; H. D. Senior, M.B., F.R.C.S., associate professor of anatomy, to be professor. Ernest N. Pattee, M.S., professor of chemistry in the College of Liberal Arts, has been made a member of the faculty of the College of Medicine. Richard H. Hutchings, M.D., medical superintendent of St. Lawrence State Hospital, Ogdensburg, N. Y., has been appointed lecturer on psychiatry; Ralph R. Fitch, M.D., of Rochester, N. Y., has been appointed lecturer on orthopedics; Charles V. Morrill, A.M., recently assistant in zoology in Columbia University, New York, N. Y., has been appointed lecturer on histology and embryology.

Dr. George Dock, professor of the theory and practise of medicine in the University of Michigan, has accepted the chair of the theory and practise of medicine, and clinical medicine, in the medical department of Tulane University, Louisiana.

Professor Ernest L. Ohle, B.S. '02, M.E. '05 (Case), who has been head of the department of mechanical engineering, and professor of steam engineering, at the State University of Iowa since 1905, has been appointed professor of mechanical engineering at Washington University. This professorship was made

vacant last summer by the resignation of Professor Fernald. Mr. William H. Roever, B.S. (Washington, '97), Ph.D. (Harvard, '06), has been appointed assistant professor of mathematics to take the place of Dr. Wernicke, who has resigned. Dr. Roever has been for the last three years instructor in mathematics at the Massachusetts Institute of Technology.

DISCUSSION AND CORRESPONDENCE

MEANING OF THE SPANISH WORD GAVILAN

IN a recent translation of a Spanish manuscript in the Bancroft Library of the University of California, entitled "A Mission Record of the California Indians," by Dr. A. L. Kroeber,[1] the following sentence occurs (p. 4): "They have a great desire to assemble at a ceremony regarding a bird called vulture (gavilan)." And in a foot-note it is stated that the bird "is more probably the eagle than the California condor, which the word gavilan properly indicates."

As a matter of fact the word *gavilan* means neither eagle nor vulture, but among Spanish and Spanish-Mexican people is the ordinary common every-day word for hawk. In the same language eagle is *aguila* (pronounced *ag'-il-lah*), but the California condor has no name (because it does not inhabit either Spain or Mexico), although the Spanish-speaking people of southern California usually call it *vultur*, or *vultur grande*.

There is no doubt, however, that several of the early Mission Padres failed to distinguish the eagle from the large hawks, and used the name *gavilan* indiscriminately for both; hence Dr. Kroeber is entirely right in assuming that the ceremonial bird of the Mission Indians of Southern California is the eagle. It is the golden eagle (*Aquila chrysäetos*).

In another place in the same article (p. 7, foot-note) Dr. Kroeber states: "Boscana, however, describes the bird as much resembling the common buzzard, but larger, which clearly makes it the condor." This seemingly natural inference is entirely erroneous. Buzzards are large hawks—not vultures—and the bird we in America call "turkey-buzzard" is not a buzzard at all, but a vulture. Boscana's "common buzzard" is a large hawk closely related to our red-tail, and the bird he described as "much resembling the common buzzard, but larger," was of course the golden eagle. Had he meant the turkey-buzzard he would have used the Spanish-Mexican word *aura* (pronounced *ow'-rah*), which is the name by which the turkey-buzzard is known among the Spanish-speaking people of California.

C. HART MERRIAM

[1] *Univ. of Calif. Publications*, American Archeology and Ethnology, Vol. 8, No. 1, May, 1908.

QUOTATIONS

PROFESSORS' SALARIES

THE finger tips of that virgin science, comparative college economics, have again been kissed by the investigators working for the Carnegie Foundation. "The Financial Status of the Professor in America and in Germany" is the theme of that institution's second bulletin, and the statistics therein arrayed baptize the new field of research with the good old family name, "the dismal science." The scenes unrolled do not conduce to gayety or pride. About a third of all American colleges report that their full professors receive an average salary of less than $1,000 a year, while a scant half confess to paying between $1,000 and $2,000. Elaborate computations, based on fairly complete evidence, show "that an American teacher who has gone through college, taken a post-graduate course and prepared himself for the profession of teaching may hope to obtain at the age of twenty-eight a salary of $1,250, at thirty-one a salary of $1,750, at thirty-three a salary of $2,250, and at thirty-five—at which age the able man will have gained his professorship—a salary of $2,500." His German colleague, having survived the long ordeals of the *Privatdocent*, receives an income whose purchasing power is about 50 per cent. greater.

But such summaries bring few new griefs; everybody has long known in a general way that American college professors as a class have to seek odd jobs during vacation and

evening hours in order to keep alive. The details, however, upon which this common knowledge is built must bring it home with a sting to the alumni of almost every *alma mater*. The policy of many colleges resembles only too faithfully that of the "university" which, while building a gymnasium with $400,000 raised by mortgaging its campus, pays its full professors an average yearly salary of $1,806 and employs only one instructor for every twenty undergraduates. On the other hand, Haverford College finds scarcely an imitator courageous enough to foreswear stadia and a hundred pompous "special courses" for the sake of paying its professors an average of $3,440 and having an instructor for every 6.5 students.

Every college man is invited to learn from the statistics how his old teachers are being treated. Publicity is the first step toward the overthrow of the painful policy which makes one professor give twenty-five lectures a week, forces another to house his family of four in a six-room flat five flights up and compels a third to do typewriting in order to pay for a small insurance policy. If the Carnegie Foundation could only send its bulletin to every man who ever emitted a class yell, college trustees might soon be dissuaded from building marble halls with teachers' salaries. In saying this we do not forget the many instances in which the almost necessary acceptance of a gift or legacy is embarrassing because of the expense which results from the conditions attached to it. College faculties might also abandon the fatuous plan of multiplying courses to allure freshmen and prevent professors from indulging in research and constructive work. Perhaps this would be attained still more easily if the bulletin were supplemented by a table showing what percentage of college instructors enjoy private incomes. If there is any evidence that the well-to-do, simply by virtue of their being well to do, have conspicuously superior chances of getting and holding academic places, the question of professorial salaries may have to be faced and answered as a problem of democracy.—*New York Tribune.*

SCIENTIFIC BOOKS

EVOLUTION OF NIAGARA FALLS[1]

The latest and most elaborate study of the physical history of Niagara is issued by the Geological Survey of Canada. Dr. J. W. Spencer, who decades ago had made important contributions to the subject, renewed his attention in more recent years and was commissioned by the Survey to give it monographic treatment. The outcome is an attractiv[2] volume of five hundred pages, illustrated by excellent and appropriate views and maps. It deals primarily with the history of the recession of the cataract from end to end of its gorge. As a foundation for that history it describes with much detail the local physical features, and discusses the contemporaneous distribution and discharge of waters in the region of the Upper Lakes, as well as the sequence of water levels in the Ontario basin. As a sequel to the history it computes in years the time that has elapst since the river and cataract came into existence. Subsidiary to the question of time are chapters on the present rate of recession of the falls and on the rainfall and run-off of the Erie and Huron basins. Less closely related to the central theme are chapters on pre-glacial drainage, the origin of the Laurentian Lakes, the utilization of the river for the generation of power, and the position of the international boundary line. There is a discussion of the present stability or instability of the land in the Great Lakes region, with the conclusion that no earth movements have occurred in modern times.

In the study of local features a series of soundings were made with apparatus of the Kelvin type—the only type adapted to the exploration of waters in violent commotion. These showed a depth in the Whirlpool of 126 feet and a maximum depth, near the foot of

[1] "The Falls of Niagara; Their Evolution and Varying Relations to the Great Lakes; Characteristics of the Power, and the Effects of its Diversion," by Joseph William Winthrop Spencer, M.A., Ph.D., F.G.S. 1905–6. Geol. Surv. Canada; Ottawa, 1907.

[2] The recommendations of the Simplified Spelling Board are followed in this paper.—G. K. G.

Goat Island, of 192 feet. Borings also were made, in the region of the pre-Niagara channel from the Whirlpool to St. David; and the crest of the Canadian fall was remapt.

The oldest view of the falls, a view based on the observations of Father Hennepin in 1678, represents a jet as pouring from the western shore athwart the face of the Canadian sheet. In a general way the sketch is crude, exaggerated and untrustworthy, but this particular feature is of so unusual a character as to encourage the belief that it corresponds to something that Hennepin actually saw—some peculiarity in the cataract which no longer exists. Spencer has been able to connect it with an old hollow or channel on the Canadian shore, a hollow now filled and effaced, and by means of this connection infers the approximate position of the cataract more than two centuries ago. He thus obtains an additional datum for the computation of the average annual recession of the falls in modern times and secures a rough but valuable confirmation of the result based on the definit surveys of later years.

There is wide interest, both popular and scientific, in the problem of the age of Niagara, or the time that has elapst since the cataract began, at the cliff near Queenston and Lewiston, the excavation of the gorge; and the fact of that interest is the reviewer's excuse for giving special attention to the author's discussion of this question. Spencer treats the subject at considerable length, and has much confidence in the result of his computations—an estimate of 39,000 years. "Slight variations on one side or the other are probable, but under the conditions, all of which are now apparently known, the error in calculations will not exceed ten per cent." (p. 11). The reviewer unfortunately finds himself unable to share this optimistic view.

The general plan followed in the computation is this: The present average annual rate of recession of the Canadian fall is estimated from maps made in 1842 and 1904–5. This rate is associated with a particular hight of the fall and with a particular volume, or discharge, of the river. At earlier stages in the history of the cataract its hight was different, and the discharge was different; and the computations make allowance for these differences. The differences in hight were connected chiefly with the southward dip of the strata, and with the variable altitude of the base-level afforded by standing water in the Ontario basin; and the range of hights was from 35 to 280 feet, the present effectiv hight being 180 feet. The differences in volume were all in one direction. During the early part of the period of recession the water of the Huron and higher basins reacht the sea by a different route, the Erie drainage only flowed thru the gorge, and the discharge was 15 per cent. of the present. At a later epoch there may have been a temporary diversion of a fraction of the Huron discharge, reducing the river to 67 or 75 per cent. of its present volume. To combine these various factors, the gorge is divided into sections, each section is computed by itself, and the whole is summed.

The principle on which allowances are made for differences in the hight and discharge of the cataract is thus stated (p. 350): "According to mathematical laws, erosion is proportional to the hight of the falls and the volume of the river, provided other conditions remain constant." The context interprets "erosion" in this formula to mean rate of recession, and "volume" to mean discharge; so that the law may be more definitly stated: Rate of recession is proportional to the hight of the falls and the discharge of the river. As the energy of the cataract (per unit time) is measured by the product of hight, or head, into discharge, it is implied that *the rate of recession is proportional to the energy of the cataract.* (In a footnote Spencer says "The erosion varies with the mass and square of velocity," which also implies that it is proportional to the energy.)

I put the law into this form for the sake of comparing it with the experience of mechanical engineers. The cataract is a natural engin, and the erosion and recession correspond to what Rankine calls "useful work" in the discussion of artificial engines. As the ratio of the useful work rendered by an engin to the energy it receives is the "efficiency" of the engin, so the quantitativ relation between the recession of the cataract and its energy is

the efficiency of the cataract (in relation to recession). To say that the rate of recession is proportional to the energy is equivalent to saying that the efficiency of the cataract is constant, that it does not change with variation of energy. Now the efficiencies of engines of human construction have been elaborately tested, and they have been found to vary, and vary greatly, with the energy received. Usually the efficiency increases as the energy increases; and an engin with constant efficiency would be a striking exception. Not merely does Spencer's supposed law fail to find support in engineering experience; it is contradicted by it. If the Niagara engin corresponds in this respect to the great majority of man-made engines, the error introduced in the computations by the use of a false law is one tending toward undervaluation of the age of the cataract.

It would perhaps be more pertinent to compare the Niagara engin with other physiographic engines, but in general the efficiencies of such engines have not been investigated. The solitary exception is that of running water regarded as a carrier of detritus, and it happens that the unpublisht results of a study of this engin (Science, XXVII., 469) are in my possession. Drawing upon them, I am able to say that the efficiency of a stream in the work of transportation rises and falls as its total energy rises and falls, and not only that, but it rises and falls with each of the two factors of energy specified by Spencer, the head and the discharge. If the efficiency of Niagara in producing recession varies according to the same law as the efficiency of a river in transportation, Spencer's estimate of the age of the river should be multiplied by a factor larger than four (assuming, of course, that his other data are accurate).

If the quantitativ data were adequate, the question of the law of efficiency might be discust in a more satisfactory way by studying the American fall in comparison with the Canadian. The mechanical energy of the American is much less than that of the Canadian; and its rate of recession is also much less. By computing an efficiency factor for each fall it is evidently possible to obtain two points on an efficiency-energy curve and thus throw light on the way in which efficiency varies with energy; and the method is peculiarly applicable because the computed energy of the American fall does not differ greatly from the computed energy of the main cataract during the longest division of its history. Calculated from Spencer's data, the energies of the American and Canadian falls, respectivly, are as 1 to 14, and the rates of recession are as 1 to 7, the efficiency of the American being twice that of the Canadian. Had Spencer used this method, or had he based his earlier rate of recession on the American instead of the Canadian fall, his result for the age of the cataract would have been nearer 20,000 than 39,000 years.

But unfortunately the data needed to apply this method do not really exist, the most serious defect being in the measure of the rate of recession of the American fall. Spencer's estimate is 0.6 ft. a year, but is dependent on the map of 1842, which has been shown (Bull. 306, U. S. G. S.) to involve a serious error. The records made by relativly accurate surveys (1875 to 1905) indicate that the recession is so small that its amount is maskt by errors of survey; and a study of the fotografic record (1854–) yields no sure determination of an actual change in the crest line of the fall. It may with confidence be said that 0.06 ft. a year is nearer to the truth than 0.6 ft.; but no definit estimate is warranted. In the judgment of the reviewer, the rate of recession is so small as to indicate that the efficiency of the American fall is much less than that of the Canadian.

Thus in three ways—by comparison with man-made engines, by comparison with river work in the carrying of detritus, and by contrasting the Canadian fall with the American —it is suggested or indicated that the efficiency of the Niagara engin, instead of being constant, increases with increase of energy and decreases with diminution of energy. If the true law were known its application would probably enlarge the time estimate.

But while the discovery of the real law of efficiency would be a notable contribution to the problem, it would not remove every dif-

ficulty. In its proper application there would be need to take account of various qualifying conditions, not all of which are readily evaluated. Among them are: (1) The width of the gorge as affecting quantity of erosion. From a gorge 1,000 feet wide twice as much rock must be excavated as from a gorge 500 feet wide in producing a recession of the falls of one foot. (2) The depth of the gorge, from crest of fall to bottom of pool, as affecting quantity of erosion. (3) Concentration of flow as affecting efficiency. For the same discharge and the same hight of cataract, a narrow, deep river is a different engin from a broad, shallow river, and probably has a higher efficiency. If, for example, the cataract were now so broad that the depth of water on its crest was nowhere greater than in the American fall, the rate of recession would be only that of the American fall. (4) Thickness of the capping limestone as affecting efficiency. Where the cap was relativly thick, the quantity of fallen fragments, by serving as pestles for grinding, may have promoted erosion; or, when the river was small and feeble, the fragments may have cumbered the way and interfered with erosion. (5) The relation of the Medina sandrock to efficiency. When the pool hollowed by the cataract reacht only to the sandrock the primary erosiv attack was on the upper shales; when the cataract penetrated the sandrock the primary attack was on the lower shale, and the upper shales were partly protected by the sandrock. The change in method of erosion may have materially affected the rate. Spencer's computations do not include data dependent on these variables.

The determination of the volume of the river at various times involves the correlation of parts of the gorge history with stages of lake history in the Huron and associated basins, so that the lake history constitutes an essential factor. F. B. Taylor, from a study of certain features about the strait connecting Huron and Erie, inferred that the pass, after having once been crost and eroded by a great river, was for a time laid bare. Spencer, from an independent study, infers that from the time when Huron water first overtopt the divide it has been continuously tributary to Niagara. The facts adduced by Taylor (*Proc. A. A. A. S.*, 1897, 201–2) appear to the reviewer demonstrativ, but space can not be taken to discuss the matter. Quite recently Taylor, in summarizing the results of extensiv studies made in later years (SCIENCE, XXVII., 725), states that the St. Clair-Detroit channel is now occupied by a great river for the third time instead of the second. Pending the publication of his data the question may be regarded as open, but if his announcement is sustained—that Niagara has thrice instead of once carried large volume, and twice instead of once run small—Spencer's computation will need still further reconstruction.

The Niagara problem resembles other scientific problems in that the enlargement of knowledge leads to the recognition of complexity. It differs from many geologic problems in the great extent of its available data. In all the regions covered by the lakes with whose changes it is concerned, those changes were the latest geologic events, so that their evidences overlie all earlier records. They may not be so plain that "he who runs may read," but they are so clear and full that the patient observer can bring together a complete, coherent, demonstrativ body of data. As the facts are gradually assembled and interpreted an intricate history is developt, a history interwoven on one side with that of the oscillating and waning ice-sheet, and on the other with that of Niagara. The complete correlation of Niagara and the establishment of its chronology promis not only to tell us its age, but to give fairly definit dates to various events in the later Pleistocene history of eastern North America, and to assist the imagination in its broader conceptions of geologic time. Truly the problem is not an unworthy one.

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The Dancing Mouse: A Study in Animal Behavior. By ROBERT M. YERKES. New York, The Macmillan Co. 1907. Pp. xxi + 290.

The comparative anatomist, the zoologist and the human psychologist are rapidly ac-

cepting the belief that a fact of animal behavior can no longer be surely ascertained by incidental observation. The tendency, however, still to use the now often worthless "notes" of the nature lover and of the old-time naturalist has not completely passed away. For instance, whenever the psychologist needs to find facts concerning phylogenetic expressions of consciousness to illustrate certain well-marked lines of development discovered in the study of the growth of the human mind, he is tempted to resort to the use of this discredited material. The same tendency is exhibited by the anatomists whenever there is need for correlating structure with function.

There is growing a stronger and stronger inclination on the part of both the psychologists and the biologists, of this country at least, to wait patiently for the much needed information about the behavior of animals until the student of behavior can supply it by the use of experimental methods. The process of obtaining facts in this way is admittedly slow; but to those who doubt that there is growing up a body of studies, scientifically made and controlled, we recommend the perusal of Yerkes' book on the dancing mouse.

This book, while not broad in its general implications, is nevertheless a study valuable alike for its history of the development of special problems in the study of animals and for its account of the methods of solving them. Were the book written wholly for the benefit of the investigator trained in the field of comparative psychology, it would need criticism on the score of a too detailed description of methods and apparatus which, later on in the course of the study, are often discarded for better ones. But this manner of presentation has its advantages in that it shows to the novitiate the difficulties and discouragements which may lie in the way of the student of behavior.

The author begins his study of the dancer by an introduction to the literature on the origin and the life history of this interesting animal. The historical research into the origin of the dancer indicates "that a structural variation or mutation which occasionally appears in *Mus Musculus,* and causes those peculiarities of movement which are known as dancing, has been preserved and accentuated through selectional breeding by the Chinese and Japanese, until finally a distinct race of mice which breeds true to the dance character has been established." The age of the race is not known, but it is supposed to have existed for several centuries.

In following chapters, the dance movement is discussed in detail. After sifting the anatomical evidence, Yerkes concludes that no structural variations existing in the ear or in the central nervous system are sufficiently pronounced to account for the dancer's peculiar types of movement. Certain possible peculiarities of structure appear when the ear of the dancer is compared with that of the common mouse, but these variations, at least according to the researches of several prominent investigators, consist neither in the absence of certain of the semicircular canals nor in the presence of neural degenerations in the cochlea, vestibule and auditory pathways. Yerkes points out the fact that our exact knowledge concerning the structure of the auditory apparatus of the dancer is all too meager. What apparent facts have been brought out by certain investigators are hotly contested by certain other investigators.

The adult animals are totally deaf; the tests made in support of this point are complete and adequate. The young animals, on the contrary, do react to auditory stimuli during the third week of life. In a few individuals the response to such stimuli was not obtained either at this or at a later age. The deafness of the adults is especially interesting in view of the fact that the young animals can hear and that the cochlea even of the adults appears not to be degenerated.

The main contributions to the field accruing from Yerkes' book come from the tests of the brightness and color vision of the dancer. The dancer was found to be quite sensitive to changes in brightness. It can readily discriminate white from black and, with some difficulty, Nendel's gray paper No. 10 from No. 20. After many tests, Weber's law was

found to hold approximately for the brightness vision of this animal. (The discussion leading up to the demonstration of Weber's law is prolix and not clearly written.) The results of the tests on the color vision of the dancer make it somewhat problematical as regards whether this form has the power to discriminate between chromatic stimulations on the basis of wave-length alone. The author thinks that there is some evidence at hand to show that the mouse differentiates the red end of the spectrum from the other regions. The red end of the spectrum seems to have a low stimulating effect. Whether this is true in the case of other mammals or not remains for further tests to decide. The experimental demonstration of the fact is difficult to make. The safest test to make, it seems to the reviewer, is to determine the reaction threshold of the animal to all the hues of the spectrum and on the basis of these determinations to construct the luminosity curve of the dancer's spectrum. The calibration of the white value of such minimal chromatic stimulations would be exceedingly difficult. The fact is dwelt upon at some length, because if it is true that the luminosity curve is different in different animals (and different even from that of the totally color-blind human being), then the inference that equality of brightness of certain hues in man means equality of brightness of those same hues in animals has no basis in fact. The results which Yerkes presents, however, make it extremely problematical whether any other investigator up to Yerkes has ever touched the problem of color vision in animals.

In the chapter on the rôle of sight in the daily life of the dancer, Yerkes makes tests to determine the relative importance of the various senses which are employed in learning the maze. The maze affords an almost ideal form of problem for this purpose. It offers control of the sensory-motor adjustments without at the same time introducing difficulties which are unsuited to the motor capacities of the animal. In learning the labyrinth, the author states: "It is safe to say, then, that under ordinary conditions habit formation in the dancer is conditioned by the use of sight, touch and smell, but that these senses are of extremely different degrees of importance in different individuals." The reviewer feels that this conclusion is not well grounded in experimentation. To his mind at least, Yerkes has not shown how and to what degree vision, smell and contact stimulations are essential factors in learning the maze. Such impressions, while possibly assailing the animal at every turn in the maze, might be as wholly extraneous to the learning process as is the impression of the flying bird to the hound hot upon the scent of his chosen quarry.

Under habit formation, Yerkes takes up in detail the dancer's ability to learn various forms of labyrinths, to climb ladders and to form discrimination habits (white-black). A satisfactory account of the learning process as a whole is given. Tables of times, errors, etc., are appended so that the learning processes of the dancer can be compared with those of other animals. Indeed, Yerkes's method of presentation might well serve as a guide for the work of future investigators who may deal with this part of the field of behavior. There is need all through our work of standard apparatus and standard methods of experimentation as well as of conventionalized forms of presentation of results.

It is of interest to note that the dancer's method of learning is one of trial and error; there is no tendency on the part of one animal to imitate the acts of another. Putting the dancer through does, however, seem to hasten the formation of an association.

An interesting account is given of the efficiency of training methods. Shall we give an animal at work upon, *e. g.*, the white-black discrimination test, two, ten, twenty or more trials per day? The index of efficiency is given as follows:

For 2–5 trials per day	81.7 ± 2.7
For 10 trials per day	88.0 ± 4.1
For 20 trials per day	91.0 ± 5.3
Continuous test	170.0 ± 4.8

Yerkes suggests that it would be interesting to compare the efficiency of training methods in terms of the duration of the habit. This

would have to be done before we could state the general value to the organism of the various methods of training.

In determining the dancer's power of retaining discrimination habits, the author found that a white-black habit may persist during a period of from two to eight weeks of disuse, but that such habits are rarely perfect after an interval of four weeks. The retention of the color discrimination rarely persisted in perfect form for more than two weeks.

Having determined the periods of persistence of such habits, the author next undertook to find out whether training, the results of which have wholly disappeared so far as memory tests are concerned, influences the reacquisition of the same habit. It was found that the ten dancers tested had so lost the habit of the white-black discrimination at the end of a rest interval of eight weeks that memory tests furnished no evidence of the influence of previous training; retraining brought about the establishment of a perfect habit far more quickly than did the original training. Indices of modifiability are given both for the males and for the females, for the learning and for the relearning. The general conclusion issuing from this study is: that the effect of training is of two kinds, the one constitutes the basis of a definite form of motor activity, the other the basis or disposition for the acquirement of a certain type of behavior.

A chapter each is devoted to individual, age and sex differences, and to the inheritance of forms of behavior. Yerkes obtained satisfactory evidence from individuals of one line of descent pointing to the fact that, in their case, a probable tendency to whirl to the left is inherited. In regard to the inheritance of individually acquired forms of behavior, the author states that descent from individuals which had thoroughly learned to avoid the black box gives the dancer no advantage in the formation of a white-black discrimination habit.

In conclusion, we may say that aside from its general usefulness as a reference book for the research student, the book forms a valuable guide to the technique of experimentation upon animals. There is one defect in the book which certainly makes it lose in value for this latter purpose. This defect lies in the over-favorable emphasis given to the method which employs punishment rather than some form of reward (food, etc.) as an incentive. The reviewer feels that Yerkes has not fully justified its claims to priority even for use with the dancer, much less its value as a substitute for other forms of incentive in experiments upon higher mammals.

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SPECIAL ARTICLES

THE ESSENTIAL MEANING OF D'ALEMBERT'S PRINCIPLE

Newton's second law of motion is expressed in the fundamental form, using C.G.S. units,

$$\sum_0^X (\Delta X)_E = \sum_0^m (\Delta m \ddot{x}). \qquad (1)$$

The necessary range of the two summations is determined without ambiguity, by the conditions of the problem selected for discussion. The first sum must include every element of external force parallel to a fixed line brought to bear upon any portion of mass within the system, either by a process equivalent to surface distribution at the boundary, or by volume distribution. The second sum covers every part of the system's mass, and no mass external to the system. Equation (1) presents Newton's thought that the physical agencies active (forces) are measurable in terms of one particular result—accelerations produced in masses—other effects, if any, being ignored in the equation. What d'Alembert put into clear relief, when he announced his principle covering "lost forces," is the unimpaired validity of the equality, after eliminating all self-canceling elements from the force-sum. This removes from consideration all inner forces always, and items of external force in certain cases. The second

member of the equation then measures the remainder of effective force only, and exhibits the necessary magnitude of the equilibrant that would change the conditions of the problem from those of acceleration to those of equilibrium, or zero acceleration. The "reversed effective force," if superposed upon the forces actually operative, says d'Alembert, would prevent the actual accelerations, and bring about equilibrium that did not in fact occur. This conception of equivalence between the differing modes of statement in the two members of such equations is prominent with d'Alembert and Lagrange, and entirely in accord with out every-day use of equations of motion to evaluate any one of the three quantities force, or mass, or acceleration, when the corresponding values of the two others are known.[1] The advance made by d'Alembert, therefore, is in the direction of devising a static measure for unbalanced forces by generalizing the procedure when we determine weight active by hanging a body from a spring balance. It is parallel to the zero method of the laboratory, that seeks the measure of any unknown quantity in terms of independent conditions adjusted to compensation of its effects. This point of view sets in a proper light the limited sense in which d'Alembert's principle brought dynamics within the scope of statical equations, and disposes effectually of the obscurity or confusion involved in "forces of inertia," or the recently substituted term "kinetic reaction." The extension of d'Alembert's principle to modern generalized dynamics does not modify essentially this conception of the method; we are still dealing with relations between force and inertia—the doing of work, and the quality of storing energy in a particular way. Clear thought in a new field is not furthered by meeting a paradox at its threshold; for nobody accepts literally the dictum that finite acceleration is, as a general statement, consistent with zero values of force, and force-moment, applied to a given system that has inertia.

[1] D'Alembert's "force of inertia" is merely a loose expression for (m); it does not denote $(-m\ddot{x})$. Lagrange uses the phrase "force resulting from inertia" as describing $(m\ddot{x})$, with unchanged sign. See d'Alembert, "Traité de dynamique," ed. 1758, p. x; Lagrange, "Mécanique analytique," ed. 1853, Vol. 1, p. 282.

Equation (1) may be recast mathematically in several ways; and some of its equivalents, being adapted more closely to certain aspects of physical thought, are obviously helpful as well as legitimate. But for clearness the name "equation of motion" shall be confined here to the above primary mode of formulating the idea. This was adopted by the old masters as segregating causes from results, terms of each class appearing by themselves in one member of the equation. We may describe these as "force terms" and "mass-terms" respectively. So soon as homogenousness in this sense is disturbed, the equation is altered in *prima facie* physical meaning. Even removing terms from one member to the other; so that a force-term is now interpretable as a mass-term, or *vice versa;* may be regarded as passing to a new problem, concerned with different masses, or modified forces, or a new classification of the effects of force. Some typical instances are the following, purposely taken on familiar and elementary ground:

1. Denoting by (P) and (R) the aggregates of positive and negative external force, respectively, thought of as acting on a single mass (m), for simplicity, we have the type

$$P = R + m\ddot{x}. \qquad (2)$$

Here the negative forces have been transferred to the second member, and the equation now expresses directly the fact that the forces (P) overcome the resistances (R), and produce acceleration as well. (R) may represent dissipative or conservative agencies. If the latter, equation (2) is preliminary to expressing storage of energy in both forms.

2. Subtracting (R) from both members of equation (2) gives

$$P - R = (R - R) + m\ddot{x}. \qquad (3)$$

This puts to the front the idea that the total force $(P - R)$ sets up static stress $(\pm R)$ to an extent determined by the resistances, the remainder becoming effective as a volume dis-

tribution of force producing local acceleration. The connection of equation (3) with the lost forces of d'Alembert is visible at once.

3. Separate the forces to which magnitude may be assigned arbitrarily from those whose magnitudes are fixed by conditions of the system like displacement, velocity, acceleration. Call the former group (A) and the latter (S). Then the form of equation

$$A = S + m\ddot{x} \qquad (4)$$

makes the second member a function of elements specified for the system, while the first member is independent of such elements. Such a segregation is convenient for mathematical handling of the differential equation, but (A) and (S) are both external forces, in the original sense of that term. We need, perhaps, to remind ourselves of this fact, when we find (A) alone described as external, in opposition to "forces exerted upon the system by itself," or inner forces.[2]

4. The effects of a force-aggregate (X) being in general to bring about changes of magnitude in some momenta, and of direction in others, that separation of results may be indicated by the notation in both members of the equation of motion, giving

$$X = M + D = m\ddot{x}_M + m\ddot{x}_D. \qquad (5)$$

According to that supposition, then,

$$X - D = X - m\ddot{x}_D = m\ddot{x}_M = M. \qquad (6)$$

One reading of equation (6) carries out the separation referred to; it measures explicitly the force devoted to producing change of magnitude in momentum. Another legitimate interpretation connects the change in force from (X) to $(X - D)$ with a definite change of reference system. But alongside of these we find surviving still a third, to the effect that (M) is the real force-total in this case (retaining the reference system and mass unchanged), resulting from the combination of (X) with centrifugal force. A similar unclearness allows the "centrifugal couple" of Euler's equations to masquerade as an external force-moment. These forms of confusion are reasonably looked upon as survivals from the days when the process of vector addition to momentum by force was grasped less completely. The changes in direction seemed almost a side issue, to be deducted before proceeding to the serious measurement of force. We still find the thought followed without flinching to the case where (M) happens to be zero, and leaves "equilibrium" between (X) and (D).[3]

The significance of such current forms, which may justify citing them in the present connection, lies in the mingling of force-terms and mass-terms common to them all. This encourages an undiscriminating attitude transferred from the field of mathematics, toward the terms included in equated expressions, which may easily obliterate certain phases of physical thought. To inquire whether a particular distinction of this sort is profitable is one way of exercising discrimination. It is proposed to raise this question presently, as regards mass-term and force-term, especially where those conceptions are employed with the wider meaning of recent usage. We may advance toward that end by considering first the form into which d'Alembert's principle is thrown, in preparation for the equation of virtual moments,

$$\sum_0^X (\Delta X)_E - \sum_0^m (\Delta m\ddot{x}) = 0. \qquad (7)$$

How is this to be understood from the physical point of view? If their original meaning is attributed to the summations, and equation (7) is nothing but a transposition of equation (1), the second sum can not represent forces actually applied to (m), since by supposition these are accounted for completely in the first sum. Neither can this be an equilibrium equation for the mass (m), so long as the second sum does not vanish. D'Alembert, however, detected in

$$-\sum_0^m (\Delta m\ddot{x})$$

a new sense, by associating it with the other force-terms as their equilibrant. Or, follow-

[2] See, for instance, Abraham and Föppl, "Elektrizität," Vol. 1, p. 195.

[3] Goodman, "Mechanics," p. 204; cf. Klein und Sommerfeld, "Theorie des Kreisels," p. 141, etc. These instances do not stand alone.

ing a more modern tendency, that sum, again recognized as force, is regarded as due to reactions of (m) upon bodies that transmit force to it. It is clear that neither view preserves the scheme of equation (1); the first uses the real equilibrium condition of equation (7) in order to exhibit the actual departure from that condition in equation (1), and the second includes forces acting, not upon (m) but upon surrounding bodies. Either view is of course tenable, both within the original scope of the principle and in the field of modern dynamics to which it has been extended. But it is only in this peculiar sense that d'Alembert made the criterion of equilibrium a basis for the measurement of unbalanced force.

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SOME APPLE LEAF-SPOT FUNGI[1]

SINCE 1892 leaf-spot disease has been frequently reported as doing considerable damage in apple orchards in various parts of the United States. Its occurrence has been noted in fifteen different states. Very little seems to be known about the etiology of the disease. That it is a fungous trouble is indicated by the ease with which it is controlled in most localities by spraying. *Coniothyrium pirina*[2] (Sacc.) Sheldon, *Phyllosticta limitata*,[3] *Phyllosticta prunicola*,[4] *Sphaeropsis Malorum*[5] and *Hendersonia Mali*[6] have been variously reported as causing, or being associated with, the disease.

The number of fungi found fruiting on the leaf-spots is the most confusing thing in determining the real cause of the disease. In an examination of apple leaf-spot specimens belonging to the West Virginia Agricultural Experiment Station, the following fungi were found: *Coryneum foliicolum*, *Coniothyrium pirina*, an undetermined species of the Tuberculariae (found by Sheldon in the spring of 1907), *Sphaeropsis Malorum*, *Monochaetia Mali*, *Pestalozzia breviseta*, *Phyllosticta limitata*, *Torula?* sp., *Macrosporium* sp., *Ascochyta* sp., *Phyllosticta? piriseda?*, *Phoma Mali*, *Septoria piricola?*, *Metasphaeria* sp., and an undetermined species of the Leptostromaceae. Of these fungi, only the first four were common enough to indicate any economic importance. *Coryneum foliicolum* is probably the fungus which has been reported by different writers as a *Hendersonia* on apple leaves. *Coniothyrium pirina* will be better recognized as *Phyllosticta pirina* Sacc., from which it was recently transferred by Sheldon.[7] *Coniothyrium tirolense* Bubàk, a portion of the original collection of which was examined by the writer, seems identical with *C. pirina*. *Phyllosticta Mali* Prill. & Dela. var. *comensis* Tray, was found to resemble *P. limitata* in all characters except the shape of the spot, which in the former is decidedly angular. A part of the type specimen of *P. tirolensis* Bubàk on pear leaves differed from *P. limitata* by the slightly shorter spores and more gregarious pycnidia.

It seems to have been generally taken for granted that *Coniothyrium pirina* and *Phyllosticta limitata* are the most important fungi causing apple leaf-spot, exceptions noticed being the reports of Clinton[8] and Sheldon.[9] *Coniothyrium pirina* has, on the other hand, been declared by Stewart and Eustace[3] to be a saprophyte. A more detailed study of the fungus therefore became desirable.

Pure cultures of it were obtained and grown on the ordinary culture media, with varying success; they were also grown very success-

[1] Read before Section G of the American Association for the Advancement of Science, January 2, 1908.

[2] Alwood, W. B., Va. Agr. Exp. Sta., Bull. 17:62 (1892).

[3] Stewart, F. C., N. Y. Agr. Exp. Sta., Ann. Rep. 14:545 (1895).

[4] Tubeuf, Karl Freiher von, and Smith, W. C., Diseases of Plants induced by Cryptogamic Parasites, 463 (1897).

[5] Clinton, G. P., Conn. Agr. Exp. Sta., Ann. Rep. 27:300 (1903).

[6] Alwood, W. B., Proc. Am. Acad. Adv. Sci., 47:415 (1898).

[7] Sheldon, J. L., Torreya 7:143 (July, 1907).

[8] Sheldon, J. L., W. Va. State Bd. of Agr., Ann. Rep. 1:57 (1906).

[9] Stewart, F. C., and Eustace, H. J., N. Y. Agr. Exp. Sta., Bull. 220:228–230 (1902).

fully on fresh and sterilized twigs of apple, rose and plum. On sterilized twigs the pycnidia developed were often strongly flask-shaped, and in many cases hairy.

Repeated attempts were made to inoculate the fungus on the leaves of young seedling, Yellow Transparent, Ben Davis and York Imperial apple trees in the green-house, with spores taken from pure cultures on various media, and placed on the surfaces of leaves kept moist under bell-jars. Only negative results were obtained from this work, though it was continued for five months, and on leaves of widely differing degrees of age and vigor.

Inoculations were also attempted on leaf tissue which had been previously injured by various artificial means, scalding, abrasion of the epidermis, and punctures made with both hot and cold needles. Inoculation on scalded tissue was usually successful, and on abraded tissue always. Fruits of the fungus quickly appeared on tissue which had been killed by abrasion and inoculated, but the area of the leaf killed by the abrasion was seldom appreciably enlarged by the fungus. Of a number of attempts to inoculate the leaves at punctures made with needles, only two were successful. Hot needles were then used in making the punctures, small areas of leaf tissue being killed by the heat of the needle; the leaves were then sprayed with the atomizer, as in previous work, the spores spread over the surfaces of the leaves with the platinum loop, and the plant kept moist under a bell-jar. Within three to five days after inoculation a large number of the inoculated spots produced by the hot needle enlarged to three or four times their original diameter, and fruits of *Coniothyrium pirina* speedily appeared, usually in a ring near the outer edge of the spot. The fungus fruited on almost every such puncture inoculated. Checks were obtained by making a row of the hot needle punctures on each side of the mid-rib of the leaf, but placing spores only on the row on the right-hand side. A very few of the check spots on the left-hand side were evidently inoculated by spores accidentally washed over from the other side in watering. The rest of the check spots did not develop fungous fruits, and did not spread beyond the limits of the area originally killed by the heat. Punctures were sometimes made with a cold needle at the same time and on the same leaves as successful inoculations at hot needle punctures, but at only two such punctures were spots ever produced by the fungus.

These results of inoculation make it seem that *Coniothyrium pirina* is a facultative or wound parasite only, able to produce spots on apple leaves provided it has a little killed or injured tissue in which to get a start. That it causes a considerable amount of leaf-spot under orchard conditions is quite possible, but not as yet demonstrated.

An inoculation was also made on the living twig of a seedling apple tree in the green-house by making an incision in the bark and inserting with platinum loop a drop of water containing spores from a pure culture of *Coniothyrium pirina*. The wound was then wrapped with absorbent cotton, and kept moist for a number of days. Forty days later several excellent fruits of the *Coniothyrium* were found breaking through the bark at the very edge of the area injured by the incision. There was no further development of the fungus, nor was there any injurious effect noticed on the health of the shoot above the point of inoculation. This seems to confirm the statement that *Coniothyrium pirina* is a facultative parasite only. A number of subsequent attempts were made to inoculate the fungus on living apple stocks kept moist under bell-jars but not wrapped with cotton; these were uniformly unsuccessful. The trees on which these inoculations were made were nearly all growing vigorously at the time of inoculation.

The readiness with which the fungus grew on dead twigs in the laboratory suggested that it could probably be found on dead twigs in nature. On May 15, 1907, a fungus morphologically identical with *Coniothyrium pirina* was found at Cassville, W. Va., on dead twigs of a quince bush, the leaves of which were known to have borne many spots containing the fungus two years previously. Pure cultures were easily obtained from these twigs by plating, and spores taken from one of these cultures were used successfully in producing

spots on apple leaves which had been punctured with a hot needle. The fungus was later found on dead apple twigs in Morgantown, W. Va., almost touching a live branch whose leaves bore spots containing *Coniothyrium* fruits. There were but few spotted leaves on the remainder of the tree. Professor Alwood, in a letter to Dr. Sheldon which the writer was permitted to see, states that the fungus winters over on the fallen leaves. The writer has not so far been able to find fruits of the fungus on fallen leaves during the winter and spring.

Coniothyrium pirina, then, occurs in spots on living leaves of apple, cherry,[10] quince and pear,[11] and on dead twigs of apple and quince. It is able under certain conditions to produce spots on apple leaves, but nevertheless it is merely a facultative parasite, and probably does not cause the serious defoliation of apple trees in West Virginia, which has been attributed to it.[12] It seems able to winter over on twigs of apple and quince.

Since in the field *Coryneum foliicolum* gave more evidence of being important than *Coniothyrium pirina,* culture work with it was also done. The fungus was grown on the ordinary culture media, and on sterilized twigs of various kinds, including spruce twigs. On synthetic agar the hyphae at first bore conidia singly on short branches, and all the spores grown on agar were long, irregular, and with cells often subdivided, making the spores as many as seven-septate; this corresponds closely to the behavior of *Coryneum beyerinckii* recently reported by Smith. On some of the media cellular, subcarbonaceous structures developed, sometimes becoming flask-shaped with long necks. In August the fungus was found fruiting on a canker on a young apple trunk. Apparently the spores were borne inside subcarbonaceous pycnidia, but the immaturity of most of the fruits prevented definite determination of this point. A pure culture made from spores from this canker grew on agar just as did the cultures taken from leaf-spots.

Some inoculation work with *Coryneum foliicolum* along the same lines as that with *Coniothyrium pirina* gave similar results, except that the *Coryneum* gave even less evidence of vigorous parasitism than did the *Coniothyrium.* It is not likely, therefore, that it is any more important as a cause of disease.

Acknowledgments are due to Professor F. C. Stewart, Dr. Fr. Bubàk and Dr. G. B. Traverso for sending specimens, to Dr. C. H. Peck for identification of a specimen of *Phyllosticta limitata,* to Mrs. Flora W. Patterson for determination of a specimen of *Coryneum foliicolum,* and to Dr. J. L. Sheldon for advice and the use of data and specimens previously obtained by him.

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[10] Alwood, W. B., Va. Agr. Exp. Sta., Bull. 24: 23–40 (1893).

[11] Jennings, H. S., Tex. Agr. Exp. Sta., Bull. 9:26 (1890).

[12] Corbett, L. C., W. Va. Agr. Exp. Sta., Bull. 66:202 (1900).

A CYCAD FROM THE UPPER CRETACEOUS IN MAVERICK COUNTY, TEXAS

IN the fall of 1905 I found a cycad in the Upper Cretaceous of Texas. The locality was three miles north and one and one half miles west of the station called Paloma, on the Eagle Pass branch of the Southern Pacific Railroad, and about twenty miles south of Spofford. At this place the Upson clay is exposed on the east side of Sauz Creek, which joins with Cow Creek to form Elm Creek a half mile to the south. The exposure runs for a quarter mile north and south and is considerably cut up by gullies. At the north end the clay was dark and it contained a *Radiolites,* a small *Ostrea,* an *Anomia* and *Exogyra ponderosa.* This last shell is frequent over the whole exposure. Eight fragments of presumably the same silicified trunk were noted. Three of these matched by their fractures and showed a stem about ten inches wide, flattened considerably, and hollow. These three and one more fragment were all that I could carry, and they have been turned over to a specialist for study.

The clay containing these fossils has been by Dumble called the Upson clay and is described in Augustana Library Publications,

No. 6, p. 68. It is from 500 to 600 feet thick in this vicinity and the stratum of this particular exposure is included somewhere in the upper 150 feet of the formation. Some sandstone ledges appearing a mile and a half south contain *Ostrea larva* and impressions of Halymenites, and these ledges mark the beginning of the change to the overlying San Miguel beds. This trunk comes from at least 1,400 feet above the base of the Upper Cretaceous in this state. The Upson clay is underlain by about 750 feet of limestone of the age of the Austin chalk, and below this there are here some 250 feet of sediments corresponding to the Eagle Ford shales. So far as I am aware this is the only known cycad yet found in the Upper Cretaceous of America.

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SOCIETIES AND ACADEMIES

THE TORREY BOTANICAL CLUB

The club was called to order on May 27, 1908, at the Museum Building of the New York Botanical Garden at 4 P.M. by Vice-president John Hendley Barnhart. Eight persons were present. After the reading and approval of the minutes for May 12, 1908, the announced scientific program was presented. The following abstracts were prepared by the authors of the papers:

The North American Species of Zygodon: Mrs. N. L. Britton.

Attention was called to the fact that *Zygodon viridissimus* is a rare species, having been found only a few times in the high mountains of the southern Alleghanies and northern New York. It is usually sterile and propagates by septate brood-bodies, borne in clusters in the axils of the leaves. Fruiting specimens, collected by Dr. J. K. Small on the summit of White Top, Virginia, showed that the peristome is absent, though all the capsules found were either too young or too old for satisfactory determination. A comparison with specimens collected by Drummond near Hudson Bay shows that the latter belong to *Zygodon rupestris*, which is variously placed by European authors as either a species or a variety of *Z. viridissimus*. Sterile specimens of *Zygodon gracilis* have been recently discovered in North Carolina by Dr. A. J. Grout. *Zygodon excelsus*, whose fruit is also still unknown, appears to be more closely related to *Leptodontium* than to *Zygodon*.

The Acceleration of the Period of Senescence by Radium Rays: C. Stuart Gager.

In view of the fact already well known, that, as old age approaches, the size of the cell-nucleus becomes less relative to that of the cell, measurements were made to see if this relation was affected by exposure to radium rays. It was found that in cells near the root-tip of *Zea Mays* the diameter of the nucleus was 35.5 per cent. that of the cells in unexposed plants, but only 33.33 per cent. in roots exposed to radium rays. This is some evidence that exposure to radium rays accelerates the approach of the period of senescence.

A Collection of Philippine Fungi: W. A. Murrill.

A splendid collection of fungi, six hundred and thirty-seven packets in all, was recently received from the Bureau of Science, Manila, through Mr. E. D. Merrill, botanist. Previous work upon the fungi of this region was briefly sketched, and the collections of Philippine fungi in various institutions compared.

This paper will be published in full, with notes and description of interesting species, in a future number of the *Bulletin of the Torrey Botanical Club*.

An announced paper, on "Botanical Supplies in the Public Schools," was not given, on account of Dr. Hollick's unavoidable absence.

At the close of the stated program Dr. Gager exhibited some photographs of flowers, etc., taken in natural color at the New York Botanical Garden by the Lumière process. The process was briefly explained.

Dr. Murrill exhibited a specimen of "Tuckahoe," and called attention to the fact that the sporophore of a *Polyporus* had been obtained from a form common in parts of Canada, the "Tuckahoe" being a sclerotium, or a resting stage of the mycelium in mass. He would be glad to receive specimens of these sclerotia, either fresh or dried, from any locality, so that the various species, if more than one exists in this country, may be properly distinguished.

Dr. Barnhart exhibited for Mr. Nash a flowering specimen of the lace-bark tree, *Lagetta Lintearia*, a native of the West Indies. This tree is known to have flowered only once before in cultivation. An article on the specimen, and the peculiarities and uses of the lace-like bark appeared in the June, 1908, number of the *Journal of the New York Botanical Garden*.

C. Stuart Gager,
Secretary